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Regrowth Control by Injection of Growth Regulators in Seedlings of Four Tree Species[1]

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Abstract. **Topped 1- and 2-year-old seedlings of silver maple (*Acer saccharinum* L.), American sycamore (*Platanus occidentalis* L.), cottonwood (*Populus deltoides* Marsh.) and American elm (*Ulmus americana* L.) were treated with each of 10 growth regulating chemicals in the greenhouse by chemical injection. Daminozide [butanedioic acid mono (2,2-dimethylhydrazide], maleic hydrazide [1,2-dihydro-3,6 pyridazinedione] and the soldium salt of dikegulac [2,3:4,6-bis-0-(1-methyl-ethylidene)-L-xylo-2-hexulofuranosonic acid] controlled regrowth at appropriate concentrations without causing unacceptable phytotoxicity.**

Since 1973 this laboratory has been conducting research to develop methods for pressure injecting growth regulators into trees. The objective of this research is to chemically control regrowth, following mechanical pruning, as a means of reducing the costs associated with vegetation management along utility rights-of-way. Though much work has been published on foliar application of chemicals to control growth of woody plants (2,3,5,6,7,8,9, 10,11), there is little information on the effect of injected growth regulators on the rate of regrowth and ultimate foliar condition of the trees. In the studies reported here, greenhouse tests were designed using containerized seedlings of 4 rapidly growing tree species to provide knowledge of their sensitivity and relative growth response to injected growth regulators. This procedure permits year round sequential testing of seedlings and chemicals, and reduces the need to test large numbers of mature trees (an expensive and time consuming process) to determine if potential growth regulating chemcials are acceptable for field studies (1).

Chemicals used in these studies have already been shown to reduce regrowth when applied as foliar sprays on woody plants (2,3,5,7,8,9,10,11).

Tests were conducted using daminozide on silver maple, American elm, and cottonwood at 5.0, 0.5, 0.05 and 0.005 g/liter and on silver maple and American sycamore at 50.0, 5.0, 0.5 and 0.05 g/liter. Silver maple and American sycamore seedlings were treated with maleic hydrazide at concentrations of 3.0, 0.3, 0.03 and 0.003 g/liter. Dikegulac was tested on silver maple and American sycamore at 1.0, 0.2, 0.04 and 0.008 g/liter.

One- to 2-year old seedlings were potted in 15 cm plastic containers using a mixture of 2 perlite: 2 peat: 1 soil (by volume) and maintained on supplemental illumination (interrupted night regime, 10 PM to 2 AM) in the greenhouse. Pots were watered 3 times a week and fertilized once a week.

When the seedlings reached full leaf expansion they were injected with growth regulating chemicals using the technique described by Gregory (3). Just prior to chemical treatment, seedlings were randomly arranged into groups of 10, and about 1/3 of the foliage was trimmed from the top of each plant.

For each group of plants tested, a control group was similarly treated with distilled water. Each growth regulator was tested at 4 concentrations with 10 plants per concentration. Five ml of growth regulator or water for the controls, was pipetted into each serum cap. Then a stem of each seedling was wounded with a sharp scalpel in 2 places to allow the chemical solution to be taken up in the transpiration stream. The serum caps were left in place until the solution was absorbed (usually within 24 hr) and then were removed to prevent possible girdling of the young stems.

At 2-week intervals measurements were taken of height increase, number of sprouts, sprout length, and phytotoxicity. Phytotoxicity was measured subjectively on a scale from 1 to 4, and included any abnormalities of the

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Table 1. Mean Root and Shoot dry weight and root-shoot ratio of silver maple seedlings approximately 8 weeks after treatment with maleic hydrazide and dikegulac.[z]

Treatment concentration (g/liter)	Root weight (g)	Shoot weight (g)	R/S
Maleic hydrazide			
3.0	14.4*	14.9*	0.96
0.3	14.8*	23.1	0.65
0.03	16.6	24.5	0.68
0.003	17.8	25.1	0.70
Control	17.7	24.3	0.73
Dikegulac			
1.0	12.1	11.8*	1.02*
0.2	12.3	12.0	1.03*
0.04	12.4	12.5	0.99
0.008	12.6	12.7	1.00
Control	12.5	12.8	0.98

[z]10 seedlings per mean.
*Significantly different from the control by LSD, 5% level.

Table 2. Mean root and shoot dry weight and root-shoot ratio of cottonwood and silver maple seedlings about 8 weeks after treatment with daminozide.[z]

Daminozide concn (g/liter)	Root weight (g)	Shoot weight (g)	R/S
	Cottonwood		
5.0	12.2	12.6*	0.97*
0.5	12.1	12.8	0.93
0.05	12.1	13.1	0.92
0.005	12.0	13.0	0.92
Control	12.4	13.6	0.91
	Silver maple		
50.0	15.0*	16.5*	0.93*
5.0	17.7	23.4	0.78
0.5	18.0	27.8	0.65
0.05	17.4	27.2	0.65
Control	17.7	24.3	0.73

[z]10 seedlings per mean.
*Significantly different from the control by LSD, 5% level.

foliage, such as chlorosis, necrosis, dieback, or leaf distortion. Each seedling was thus given a numerical rating where 1=no phytotoxicity, 2=less than one-half of seedling with phytotoxic symptoms, 3=more than one-half of seedling with phytotoxic symptoms and 4=seedling dead. A seedling with a phytotoxicity rating of 3 or more was considered unacceptable.

Data was recorded for about 8 weeks. In 4 of the tests (silver maple treated with daminozide, maleic hydrazide and dikegulac, and cottonwood treated with daminozide) the seedlings were harvested and measurements taken of root and shoot dry weight.

Daminozide. Two tests were run with daminozide at separate times on silver maple (Table 3). Larger seedlings were used in the 1975 studies so the concentrations used for those tests were increased by 10-fold. A growth reduction of about 80%, in comparison to the controls, occurred at the 5.0 g/liter concentration in the 1974 test. Phytotoxicity ratings were acceptable for all concentrations tested (Table 3). Daminozide at 0.05 g/liter actually stimulated regrowth of silver maple in both tests.

Regrowth of American sycamore treated with daminozide was reduced by 97% with the highest concentration of 50.0 g/liter, but the phytotoxicity rating was unacceptable. The 5.0 g/liter concentration reduced regrowth by almost 40%, and the phytotoxicity rating for this treatment was acceptable at 2.5. Lower concentrations of daminozide had little effect on the regrowth of American sycamore.

On cottonwood seedlings the highest concentration of daminozide (5.0 g/liter) reduced regrowth by 80% while the phytotoxicity rating remained acceptable.

Maleic hydrazide. In 2 separate tests on silver maple regrowth was reduced by 95 to 98% at the 3.0 g/liter concentration (Table 3). Although phytotoxicity increased slightly as a result of chemical treatment, at no time was chemical injury at an unacceptable level. The lowest concentration of maleic hydrazide (0.003 g/liter) stimulated regrowth in both tests.

Regrowth of American sycamore was reduced with all concentrations of maleic hydrazide tested, but phytotoxicity was unacceptable for the 2 highest concentrations tested and close to unacceptable for the 2 lower concentrations.

Dikegulac. Regrowth of silver maple was reduced by over 88% at the highest concentrations used in this study (0.2 and 1.0 g/liter), however, the phytotoxicity rating for the highest dikegulac treatment was unacceptable (Table 3). A slight stimulation in height increase occurred at concentrations of 0.04 and 0.008 g/liter.

Regrowth of American sycamore was reduced by 42% at the 1.0 g/liter concentration of dikegulac with an acceptable phytotoxicity rating. However, the number of sprouts substantially increased as a result of this treatment.

Other chemicals. Treatment of silver maple with (2-chloroethyl)trimethylammonium chloride (chlormequat) at 5.1, 0.51, 0.051, and 0.005 g/liter, napthaleneacetic acid (NAA) at 10.0, 1.0, 0.01 and 0.01 g/liter and ethyl hydrogen 1 propylphosphonate (FMC 10637) at 10.0, 1.0, and 0.01 g/liter caused excessive phytotoxicity before growth reduction occurred. N-[2, 4-dimethyl-5-[(trifluoromethyl)=sulfonyl] amino] phenyl] acetamide (mefluidide) at the concentrations used in this study, 0.24, 0.024, 0.0024 and 0.00024 g/liter was ineffective in reducing the regrowth of silver maple and cottonwood seedlings, but phytotoxicity was no problem. The data from these tests are not included in this report.

Since α-cycloporpyl-α(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol) is not water soluble and must be maintained at a pH greater than

Table 3. Regrowth and phytotoxicity of silver maple, American elm, sycamore and cottonwood seedlings injected with daminozide, maleic hydrozide, and dikegulac in the greenhouse.

Species	Concentration (g/liter)	Regrowth (% of control) Height Increase	Sprout Length	No. of Sprouts	Toxicity rating[y]
		Daminozide			
Silver maple (1974)	5.0	22*	17*	114	2.3
	0.5	66	56*	152	1.9
	0.05	110	78*	117	2.0
	0.005	83	80	97	1.9
(1975)	50.0	11*	20*	36*	2.6
	5.0	75*	122	37*	1.6
	0.5	95	155	60	1.6
	0.05	104	128	97	1.6
American elm	5.0	17*	29*	81	1.8
	0.5	80	98	81	1.9
	0.05	122	104	100	2.3
	0.005	89	89	106	2.4
American sycamore	50.0	3*	3*	11*	3.7
	5.0	61*	55*	81	2.5
	0.5	89	91	106	2.5
	0.05	69	97	71	2.7
Cottonwood	5.0	21*	17*	51*	2.8
	0.5	68	82	94	2.6
	0.05	112	108	68	2.7
	0.005	101	99	78	2.4
		Maleic hydrazide			
Silver maple (1974)	3.0	3*	7*	21	2.2
	0.3	63	54*	86	2.0
	0.03	93	81	110	1.9
	0.003	114	102	128	2.1
(1975)	3.0	0*	0*	1*	2.0
	0.3	101	133	58*	1.6
	0.03	101	129	79	1.6
	0.003	109	200	60	1.4
American sycamore	3.0	0*	0*	6*	3.4
	0.3	24*	29*	48*	3.3
	0.03	55*	76*	52*	2.9
	0.003	57*	70*	51*	2.8
Cottonwood	3.0	4*	7*	3*	4.0
	0.3	63	157	117	3.6
	0.03	71	86	103	4.0
	0.003	104	114	113	3.7
			Dikegulac		
Silver maple	1.0	1*	10*	16*	3.2
	0.2	22*	27*	84	2.8
	0.04	129	115	153	2.7
	0.008	144	121	158	2.7
American sycamore	1.0	58*	33*	286	2.6
	0.2	86	62*	194	2.4
	0.04	95	76*	112	2.5
	0.008	102	99	106	2.2

[z]Each Value represents the mean of 10 seedlings.

[y]Based on a numerical scale from 1 to 4, where 1 = no phytotoxicity; 2 = less than one-half the seedling showing phytotoxicity; 3 = more than one-half the seedling showing phytotoxicity; 4 = seedling dead.

*Indicates values significantly less than the control, p = 5%.

7 to stay in solution, a mixture of methyl alcohol and phospate buffer was used to solubilize this chemical. As this same solvent caused considerable phytotoxicity when applied to control plants, no conclusions concerning the potential ability of ancymidol as a growth regulating chemical can be made from these studies.

Both N-4-methyl-3-[[(trifluoromethyl)sulfonyl]amino] phenyl]acetamide (fluoridamid) at 9.7, 0.97, 0.097 and 0.0097 g/liter and 2,3-dihydro-5-6diphenyl-1,4 oxathin (UNI-P293) at 7.2, 0.72, 0.072 and 0.0072 g/liter reduced regrowth appreciably on silver maple, but caused excessive phytotoxicity and, thus, the results are not included in this paper.

Dry weights. The 4 tests in which dry weights were recorded showed consistently that root and shoot weight decreased and the root-shoot ratio increased as chemical concentration increased (Tables 2 and 3). The increasing root-shoot ratio indicated that growth of stems and leaves in treated seedlings was proportionately more affected than the growth of the roots.

The most consistently effective chemicals tested in these greenhouse studies were daminozide, maleic hydrazide, and dikegulac. Daminozide at 5.0 g/liter reduced regrowth of all 4 species tested by at least 40%. Regrowth of silver maple was controlled by 3.0 g/liter of maleic hydrazide; but American sycamore seedlings exhibited phytotoxicity before significant regrowth control was obtained. Dikegulac reduced regrowth of silver maple by 78% at the 0.2 g/liter concentration. Another material, mefluidide, did not give satisfactory growth reduction at the concentrations used in this study, however, by varying the concentrations it may be possible that this chemical could effectively reduce regrowth without causing excessive phytotoxicity.

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Macronutrient Stability during Overwintering of Royal Beauty Cotoneaster and Andorra Juniper[1]

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Abstract. **Fluctuations of macronutrient levels in the leaves, stems and roots were analyzed in *Cotoneaster dammeri,* C. K. Schneid. cv. Royal Beauty and *Juniperus horizontalis,* Moench cv. Plumosa during the overwintering period. Potassium, Mg and Ca levels, in both species, maintained periods of relative stability. Tissue P levels remained stable in all tissues, while N levels in leaves, stems and roots of both species fluctuated significantly throughout the sampling period.**

Autumn fertilizer applications have been shown to influence plant growth the following spring (7, 12), indicating that tissue nutrient levels during dormancy may reflect the availability of nutrients for spring growth. Thus, sampling of woody plants during dormancy may provide a means of detecting nutritional imbalances which could be corrected by fertilizer applications prior to spring growth.

Timing of the tissue sampling procedure to coincide with periods of relative macronutrient stability has received limited attention with woody ornamentals (3, 9, 14). Studies with deciduous and evergreen crops indicate that nutrient levels are unstable during the growing season (2, 5, 8, 14, 15). Stability of leaf nutrient levels during the winter months has been reported with avocado (4, 11), mango (10) and yew (9). These reports suggest that tissue nutrient levels in woody ornamentals in late fall, winter and early spring may be more stable than during the period of active growth. The purpose of this study was to determine if K, Mg, Ca, P and N in cotoneaster and juniper tissues exhibit periods of stability during overwintering.

Uniform 1-year-old cotoneaster and juniper liners were potted in 2.8 liter plastic pots in a 2:1:1 (by volume) composted hardwood bark/sphagnum peat/sand medium on May 21, 1977, and grown in a nursery. Plants received 200 ppm N, weekly, in the form of 20N-8.6P-16.6K soluble fertilizer from May 30 until October 1, 1977. Samples were collected bimonthly from October 14, 1977 through April 17, 1978; 2 plants were selected, and combined as 1 sample, from each of 4 replications using a completely randomized design. On November 30, 1977, the plants were covered with single layers of 6.4 mm DuPont microfoam and 4 mil white copolymer. Snow was allowed to accumulate on this covering between sampling dates. Leaves, stems and roots of plant samples were forced-air dried at 70°C for 72 hr prior to recording the dry weights. After the final sampling date all samples were analyzed, by replication. Two samples from each replication were analyzed for total N in order to confirm results. One sample was analyzed per replication for all other elements. Total N was determined by the micro-Kjeldahl method, P by the vandate-molybdate

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